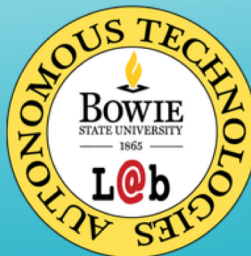




AUTONOMOUS SEASONALITY ADAPTATION

DARSANA JOSYULA, PH.D.

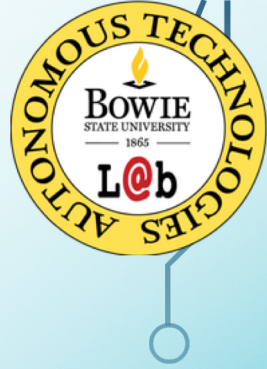
BOWIE STATE UNIVERSITY



WHAT IS SEASONALITY

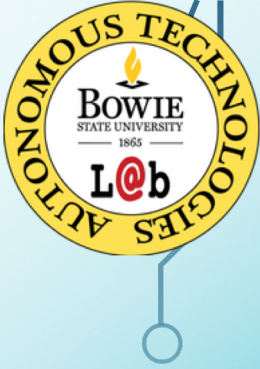


Seasonality is a characteristic
 by which recurrent patterns
 occur in time series data.



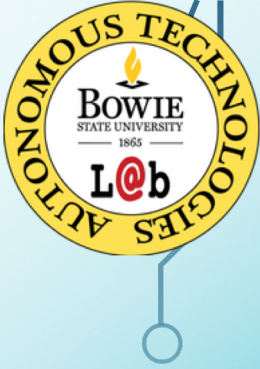
WHY SEASONALITY DETECTION

- Agents can exploit the lessons learned in a previous similar season to improve its performance when the season repeats.
 - A cognitive radar system may choose its transmission parameters based on what worked best in the previous season that had similar spectrum signals.
 - Failed transmission attempts in a previous season need not be repeated if the cognitive system can recognize the similarity of the current season.
- If the current season has never been experienced before, then it is an anomaly that requires special attention for learning further about how to behave in that season.
 - The learning that occurs during a failure can be reused for failure recovery when a similar failure occurs.



RESEARCH QUESTIONS

- How can an agent detect if it has experienced the current season before?
- How can an agent predict its next season?
- How can an agent avoid relearning its behavior when a season repeats?



WHAT TO MONITOR

- Performance
- Suggestions
- Observations
- Behaviors

PATTERNS IN TIME-SERIES DATA

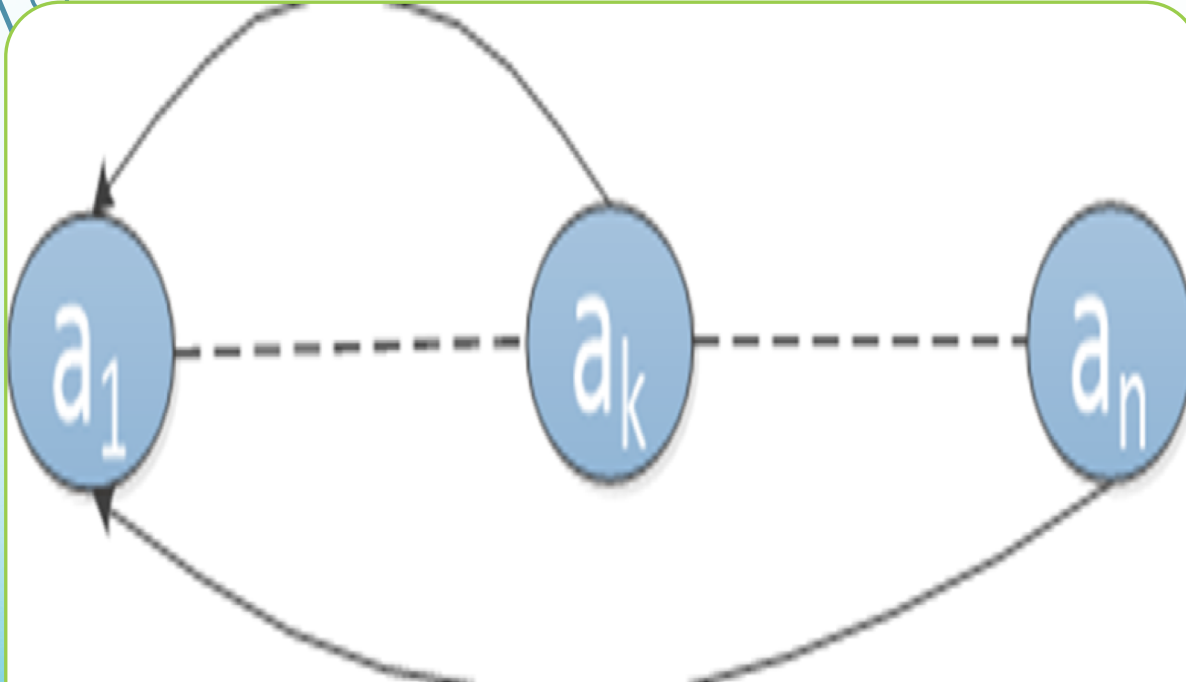


Reflexive
Pattern (Fuel
indicator data)

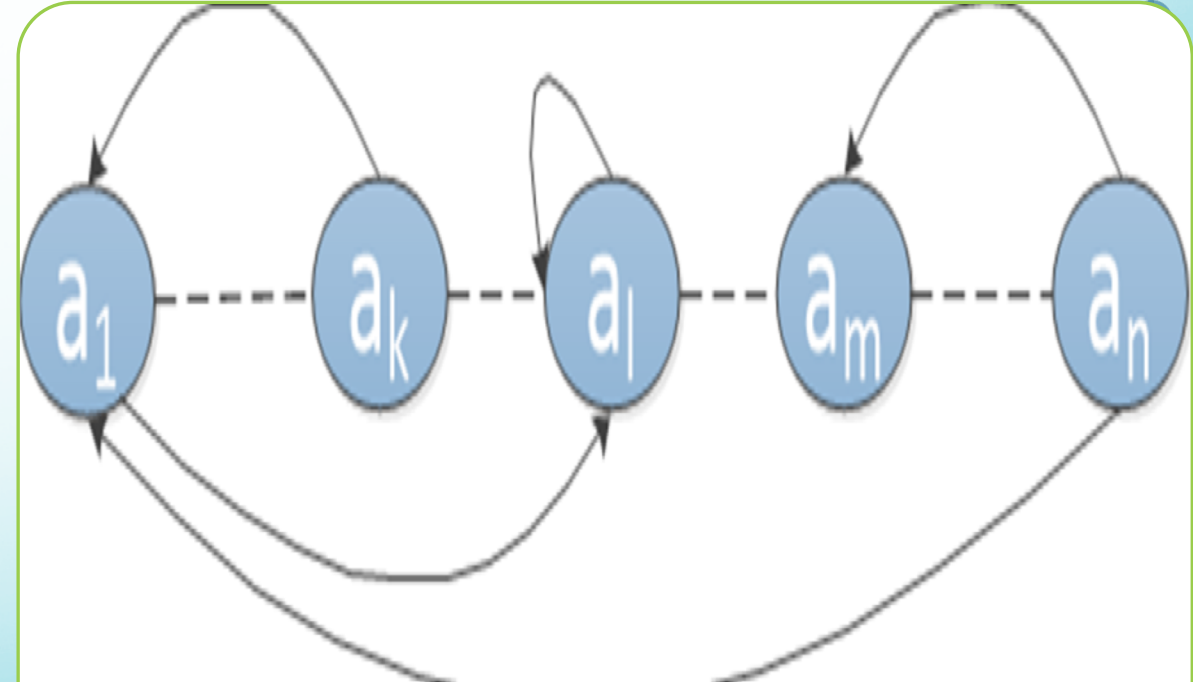


Periodic Pattern
(Weather data)

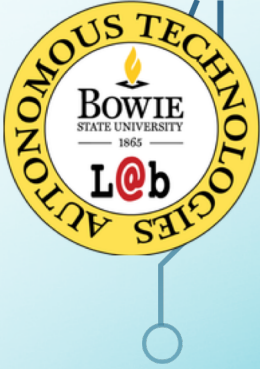
PATTERNS IN TIME SERIES



Forked Pattern (location data from a room cleaning robot that cleans an extra room on alternate days)



Hybrid Pattern (Camera data from a self-driving car)



KASAI OVERVIEW

Seasonal pattern detection service.

- Kasai accepts a sequence of temporal data as its input.

Online mode

- Detects patterns and stores these patterns as rules
- Updates existing patterns as new patterns emerge

Offline mode

- The trained Kasai is used to validate incoming data and to detect anomaly
- Any deviation from stored rules is a potential anomaly

KASAI RULES

A rule consists of:

- A Boolean predicate
- An action to be performed when the predicate is TRUE
- An action to be performed when the predicate is FALSE, often nothing

Representation

- Rule $P_x \rightarrow A_n$: If P is true perform A.

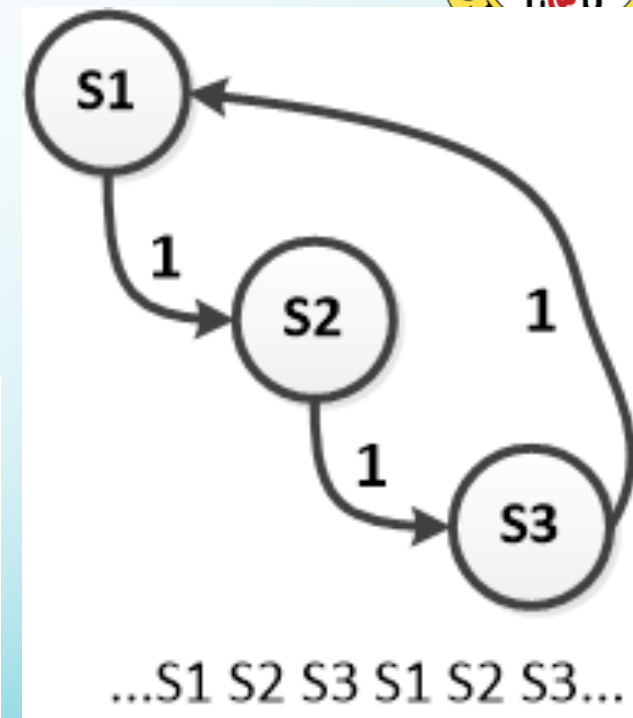
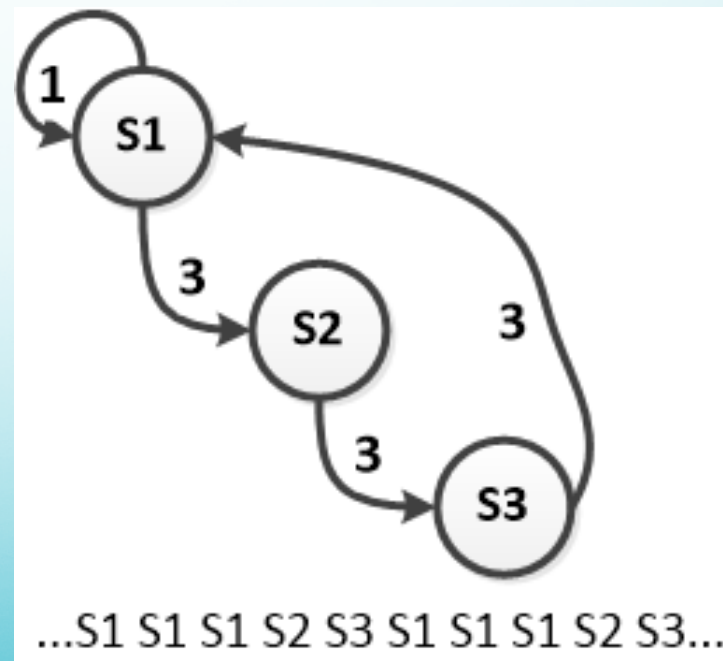
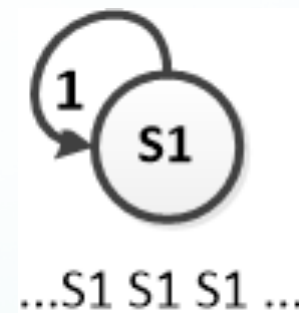
DATA SERIES TYPES

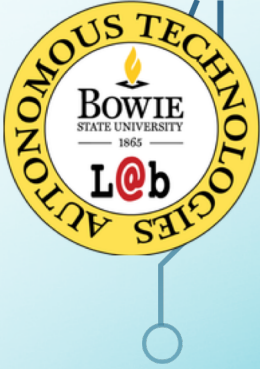


Type	Example	Grammar	Notes
Random	azbycgdhsfgh		There are no actual patterns in the data. It is not possible to describe this pattern using any combination of grammatical rules.
Reflexive	aaaaaaaa	$a \rightarrow a$	Reflexive patterns contain sequences of the same token.
Periodic	abcbcabcbcab	$a \rightarrow b$ $ab \rightarrow c$ $abc \rightarrow a$	The pattern in the data is composed of the symbols (abc) of tokens (a, b, c). It is possible to describe this sequence by using a grammar (a set of rules).
Forked	abcbabcdabcbcd	$abcbabc \rightarrow d$ $abcbacd \rightarrow a$	Seasonal patterns include trivial periodic patterns. However, symbols in the sequence form patterns. The grammar for this pattern includes the trivial periodic pattern grammar above plus these rules.
Hybrid	aaabaabkaab	$a \rightarrow a$ $aaa \rightarrow b$ $aaab \rightarrow a$ $aaabaa \rightarrow b$ $aaabaab \rightarrow k$	A hybrid sequence combines periodic, reflexive, or forked characteristics.

THE KASAI ALGORITHM

The grammar is represented as a directed graph. The nodes of the graph are the rules. The edges are directed and form a unique path through the nodes





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- K. M'Bale and D. Josyula, **Encoding seasonal patterns using the Kasai algorithm**, Artificial Intelligence Research, Vol 6, No 2, 2017

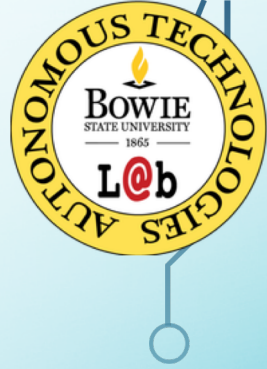
CONCLUSION

Seasonality detection and prediction are important for autonomous agents

The Kasai algorithm analyzes an input sequence to generate a set of rules that describes the input sequence

Kasai allows seasonality detection, prediction and adaptation

Multi-level Metacognition allows



ACKNOWLEDGMENTS

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THANK YOU!

